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POLICIES AND SUSTAINABILITY IN GREYWACKE QUARRIES IN NORTHERN IRELAND

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Abstract:
Northern Ireland has a substantial resource of High Polished Stone Value PSV aggregate. Exports take place to the rest of the UK and Europe. QPANI (2010) identified 183 Quarries and Sand pits within its boundaries. Fifteen of these supply greywacke. The Geological Survey of Northern Ireland (GSNI) consider the total turnover from the quarrying industry to be around £630 million per year: approximately 3% of Gross Domestic Product (GDP) (Belfast City Council, 2017). With substantial demand and a finite resource, the sustainability of greywacke demand strategies for Northern Ireland is examined. With the formation of Local Development Plans (LDP) by the council areas, this research informs on the supply and demand of Greywacke. The current LDP drafts are based mainly on environmental considerations rather than statistical information. The paper identifies that the quarries believe BREXIT will not have a detrimental effect on their trade internally but will have a negative effect on their trade with the rest of Europe. The Geological map of Northern Ireland determines the location of quarries but efficiency of vehicles can be shown to provide a 16.9% reduction in pollution through purchase of more efficient vehicles. This can be achieved through a combined single source policy document as the majority of the quarries shortly will either replace their vehicles or invest in additional ones. In relation to greywacke, reserves are robust in County Down but need examined for Mineral Extraction plans in other counties.

Keywords:
Government Procurement, Civil Engineering Procurement, Sustainability, Aggregates.

1. INTRODUCTION

Northern Ireland Land Matters Taskforce (NILMT) (2015) states that Northern Ireland (NI) is one of the *most varied and complex areas of geology in the world* resulting in a *diverse mineral heritage*. Northern Ireland has an area of around 14 000 km^2 containing three major terranes (Anderson *et al.,* 2004). The first is the Dalradian Supergroup containing the Tyrone Igneous Area and some Ordovican and Silurian sedimentary rocks (Cooper *et. al.,* 2011;Cooper

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and Johnston, 2004a). The second is in the Northeast where the Antrim Plateau is composed of Palaeogene basaltic lava with underlying Carboniferous, Permian, Triassic, Jurassic, and Cretaceous rocks (Mitchell, 2004). The final one is the Southern Uplands-Down-Longford terrane and is the one that is of interest to this study. It is formed from Ordovician and Silurian rocks (Anderson, 2004) but includes the Lower Devonian Newry Igneous Complex (Cooper and Johnston, 2004b) and Palaeogene Slieve Gullion and Mournes complexes (Cooper and Johnston, 2004c) with the greywacke (a form of sandstone) shown in Figure 1.

A Geological map of Northern Ireland (QPANI, 2010) indicates the mineral deposits are not evenly distributed across NI (Figure 1). As a result, demand often occurs at locations a distance from the quarry. QPANI (2010) identified 183 Quarries and Sand pits within NI. However, according to QPANI (2010) only sixteen of these supply Greywacke. However, one of these no longer produces aggregates. This study examined Greywacke use as it has the lowest number of quarries for any individual mineral excavated within NI. In addition, the research was limited to greywacke because of its high Polished Stone value (PSV) and therefore its use in road surfaces. Demand for greywacke from Northern Ireland is high in the UK, Europe and further, and includes the A15 extension, which connects to the Port of Rotterdam and is Europe's busiest motorway (McKeown, 2017). As a result, it is a scarce resource as there are few quarries to produce the adequate tonnage of the mineral to meet the demand in NI, the Republic of Ireland, Europe and the UK. Due to the geology, the main source of greywacke comes from County Down with eleven quarries, followed by County Armagh with two and then County Antrim and County Tyrone with one each (QPANI, 2010).

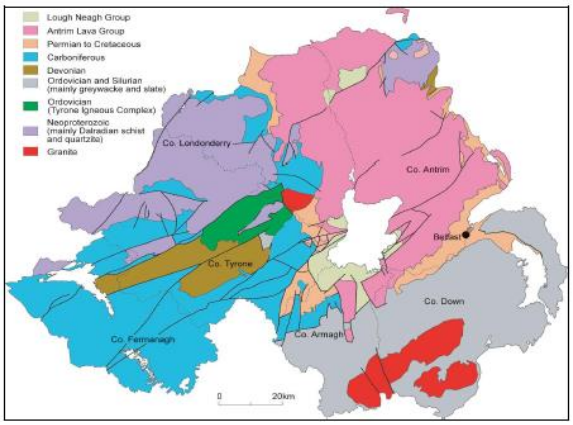

Figure 1 Mineral Deposits and quarry locations across Northern Ireland (QPANI,2010).

While the geographical locations of the current quarries are known, information on the flow of minerals in NI is not, therefore, it is difficult to accurately determine a planning policy for the Quarry industry. Currently each new planning application for a quarry does not have specific planning advice but is considered on a case-by-case basis in relation to constraints on the amount of excavation against environmental and local habitat damage. Furthermore, as a result this research needs to look at current capacities.

1.1. Brexit, Capacity and Transport

Production output of aggregates from NI were last measured prior to the economic crisis in 2008 (QPANI, 2010). QPANI (2010) showed that between Since then the recession had a major impact on the quarry sector starting in 2007, with a drop in personnel from over 5000 to 3750 in 2010. There is concern in NI that BREXIT will mean a smaller amount of major capital projects in NI and thus lower demand for aggregates (NICG, 2016). Dhingra *et.al.* (2016) states that

leaving the EU, "*would lower trade between the UK and the EU because of higher tariff and non-tariff barriers to trade*". Rafal *et.al.* (2016) further state, "*Real exports would initially drop by 8% if the UK were to lose its preferential access to the EU market*". There are concerns on the impact on the aggregates sector should BREXIT have the same effect on greywacke exports. This may be mitigated though its highly regarded PSV values. This paper seeks to examine perceptions of quarry staff of the impact of BREXIT as this has not previously been examined.

Capacity through lower demand due to BREXIT and the economic downturn is a concern in Ireland. Lower levels of construction within Northern Ireland have weakened demand. Accordingly, as previously mentioned quarries have reduced their workforce to remain lean. However, QPANI (2015) have raised anecdotal concerns from within the industry that lower demand has weakened the construction industry to the extent that if demand increased for aggregates, quarries would not be able to meet the increase in demand or have the adequate reserves in place. This piece of research is therefore important in planning and safeguarding future sites so there are adequate reserves of greywacke if the demand rises.

Transport considerations also need to be taken into consideration as the mineral sector has a high impact on congestion of roads and therefore the environment. Hill *et.al.* (2014) further identify high-energy use and carbon footprint as a by-product of the aggregates industry. Zuoa *et.al.* (2013) identify mitigation measures in order to increase sustainability and lower CO2 emissions from quarries in England and Wales.

1. Move the Quarry closer to the demand. This firstly requires a new source and planning approval to mine aggregates. Existing quarries cannot be moved and it can be seen from Figure 1 that the geology does not support this.
2. Deliver by train. The rail network in NI contains only 210KM of track and would need large financial investment to provide the suggested service.
3. Improve the vehicles so they are more environmentally friendly and efficient. This is really the only viable option in NI.

Quarry rolling stock within NI has not been previously examined in depth. For each quarry in NI the haulage miles covered will vary in order to deliver the aggregate to where the demand arises. The average distances travelled per year will be examined within this paper.

1.2. Policies and Documents

With the need to reduce CO2, Mineral planning policies need to be put into place to engender a sustainable quarry sector in Europe and Northern Ireland. While the Geological Survey of Northern Ireland (GSNI) provides information through maps, boreholes and site investigation reports, it does not provide information on the supply and demand of minerals or predict the future demand of minerals in NI. This has been identified as a knowledge gap by NIMLT (2015) who state, "*it is essential that they assess the supply and demand requirements for aggregates not only within their own council area, but also that of other council areas*". Furthermore McCabe *et. al.* (2008) indicates that the policies used for the preparation of policy such as the SEA Directive, the Planning Strategy for Rural Northern Ireland (PSRNI) and the Regional Development Strategy NI 2025 used information that did not show the demand for aggregates and relied upon information that was "*inadequately researched*" by using for example average excavation tonnage figures from the nineties.

Comparing the policies used by NI to England and Wales where policies are updated and consider issues such as production, movement and consumption (Ike and Van Der Molen, 2005), the planning policies and processes in NI need to be updated. Production, supply, demand, and the capacities and reserves of the quarries need to be examined in order to determine future requirements. Nickless *et.al.* (2014) indicate that NI is not the only place where this is the case, showing that "*Many (most) jurisdictions lack a policy framework which requires consistent*

mineral resource reporting standards". To put this into place will result in the Quarry Industry future proofing and therefore safeguarding sites where mineral access is available. To do this however, NIMLT (2015) show that future demand needs to be analysed and predicted so future reserves are adequate. QPANI (2010) shows that Policy 19 on mineral supply and demand is to be created in the future and this will cover all factors affecting the Quarry industry.

1.3. Reserves, Mineral Mapping and Greywacke Supply and Demand

In terms of minerals, Scholz *et.al* (2013) define reserves as, "*the total resources that can be economically extracted with available technology and energy under environmentally and socio-economically acceptable conditions*". They split the overall amount of a mineral into three categories: (i) reserves, (ii) resources, and (iii) geopotential, with the reserves being a subset of the other two. Resources are minerals that are currently uneconomic to extract and geopotential are resources and reserves of the future unknown at present. This paper examines expansion of the quarry sector, but is only concerned with the reserve element of mineral extraction.

As population increases within NI and as a result demand for minerals increase, it is important that new mineral reserves are discovered. Mineral mapping can help discover and safeguard sites for future excavation (NIMLT, 2015). As far back as McKelvey (1972), it was suggested that even if only provisional estimates are made this will help to aid policy decisions in relation to reserves and where there is the need to reserve certain sites for future excavation. McKelvey (1972) further suggested that when carrying out the mineral mapping, groups of resources by size, grade, accessibility of workable deposits and costs of mineral should be used to determine the best sites to safeguard. As this paper examines High PSV Greywacke quarries only, hence these are previously determined, it is only seeking to determine reserves and ability to expand at each of the quarry locations.

QPANI (2010) reported that despite the recession that demand for Greywacke was constant until the recession. Highley *et. al.* (2013) showed that Greywacke has high PSV values and the demand of such minerals for the use on roads in the UK and Europe is substantial. QPANI (2010) stated that "*approximately 600,000 tonnes of High PSV Gritstone is exported annually*". This needs to be examined more fully and incorporated into the overall needs assessment for the material. The Environmental Protection Agency (2006) used three scenarios to predict the future demand of aggregates in the Republic of Ireland by using the previous demand each year and correlating it to construction output as a percentage of the GDP. Aggregates were subdivided into two types: Primary and Secondary aggregates. Primary aggregates are directly extracted from the ground whereas secondary ones are recycled. Any assessment of future needs has to examine the percentage of each type of aggregate. This paper seeks to fill the knowledge gap in relation to aggregate supply in NI Quarries for Greywacke and relate this to the policies.

2. RESEARCH METHOD

QPANI (2010) list 16 greywacke quarries in Northern Ireland. All of the greywacke quarries were contacted as part of this research. Twelve out of the sixteen responded with nine fully completing the questionnaire (75% total response, 56.25% complete response rate). One of the incomplete responses was from a quarry designated as producing greywacke but stated it no longer produces the material and responded it had no reserve capacity of greywacke. Taking this into account the figures for response rate rise to 80% total and 60% respectively and analysis was on the 15 working quarries. Two of these quarries considered capacity was commercially sensitive information and did not complete that section of the questionnaire. Five others opted out of the study as they did not want to place information in the public domain. It should be noted that the major exporter of aggregates to Europe from Northern Ireland did not complete the survey. The findings show those who completed the survey do not export to Europe apart from

the Republic of Ireland. Rubin and Babbie (2009) state a minimum response rate of 50%. With 9 out of 16 complete responses received and 3 partially complete, this met the minimum response rate for validity. Limesurvey™, an on-line PHP and MYSQL package was used to disseminate the survey. The software allows the received surveys to be analysed.

3. FINDINGS

3.1 Findings on BREXIT

Responses were received for 12 of the 15 working quarries for these questions. The results are presented in Table 1. The results in Table 1 indicate that the majority of quarries consider that there will be a negative impact on trade with Europe including the Republic of Ireland (ROi) (66%). This confirms the negative impact predicted by models such as OECD's METRO model (Rafal *et.al.*, 2016) and the E model (Swati *et.al.*, 2016) which both predicted that BREXIT would have a negative effect on trade with Europe. However, most (77%) predicted little change and some even predicted an increase in demand within the internal market (8.33%). One quarry stated that was because "*As BREXIT is established demand for aggregates in South East England may rise as imports from Europe may fall. However capacity and efficiency to market will be crucial if Northern Ireland is to fill the market gap*". This could benefit NI quarries in partially filling the predicted gap in the future as exports to Europe are predicted to fall.

Table 1 Impact of BREXIT on the Quarrying Industry

Impact of BREXIT	Northern Ireland			England, Scotland, Wales			Rest of Europe (Including ROI)		
	No	%	+/-	No	%	+/-	No	%	+/- %
1= Large Negative Effect	0	0.00	16.67	0	0.00	16.67	2	16.67	66.67
2 = Small Negative Effect	5	16.67		2	16.67		6	50.00	
3 = No change	6	75.00	75	9	75.00	75	4	33.33	33
4 = Small Positive Effect	1	8.33		1	8.33		0	0.00	
5 = Large Positive Effect	0	0.00	8.33	0	0.00	8.33	0	0.00	0.00

Statistics provided on output in the past 5 years to these regions are provided in Table 2. What these statistics show is that the amount of gritstone sent to England, Scotland and Wales over doubles that sent to the Republic of Ireland (ROI). Therefore, the two regions where most (75%) consider that there is no change are the regions where most of the aggregate is being used in. The values in this response were received from 9 quarries and then factored up to provide a figure for all 15 quarries in Northern Ireland.

Table 2 Northern Ireland Quarry Markets

	Northern Ireland	England, Scotland, Wales	Rest of Europe (Including ROI)
Amount in Tonnes (Ave per year last 5 Years)	1293785.8	208236.2	93479.6
Factored for 15 Quarries	2156309.7	347060.3	155799.3
Total (Ave per year last 5 years)	2659169.3		

The possibility of an increase in the England Scotland and Wales market even by a small amount may therefore negate the negative impacts of cross border trade. The impact of BREXIT on the aggregates industry therefore may not be as dramatic as in other industries. However, as

the QPANI (2010) identified a 2008 value of 2,696,712 tonnes per year taking into account the economic downturn. The figures in Table 2 show that this value has remained constant since at the slightly lower value of 2,659,169.3 tonnes per year. These values confirm the QPANI (2015) statement that output has remained static since the downturn. They further confirm the QPANI (2015) and NICG (2016) concerns that owing to the reduction in staff at the quarries that should the demand increase, there will be issues with meeting it.

3.2 Findings on Capacity

Table 3 indicates the capacities and life expectancy for quarries in Northern Ireland. This indicates that County Down and County Armagh have enough reserves of Greywacke for many years. However, due to the geographical constraints in Northern Ireland the other counties are not as well off. Care needs to be taken in the Antrim Lava area shown on Figure 1 as supplies will need to be supplemented from other regions in the near future.

Table 3 Future Capacity in Northern Ireland Quarries

Quarry	Life expectancy	Amount of Greywacke in Tonnes
1	10-20 years	3000000
2	More than 20 years	500000
3	More than 20 years	20000000
4	More than 20 years	20000000
5		4000000
6	10-20 years	4100000
7	2-5 years	1500000

3.3 Findings on Transport Issues

Transport issues and fleet usage were examined during the study in order to see if the aggregates industry could minimise its CO2 emissions. Figure 2 indicates that no vehicles travel more in the Urban environment than the Rural and 41% of vehicles have an even split between Rural and Urban environments. Figure 2 results showed that the majority of the time the remaining 59% were travelling the majority of their time on rural networks: Rural 60% Urban 40% (17%), Rural 80% Urban 20% (25%) and Rural 90% Urban 10% (17%). This is determined by location and demand needs. However, on examination of fuel efficiency the impact is seen.

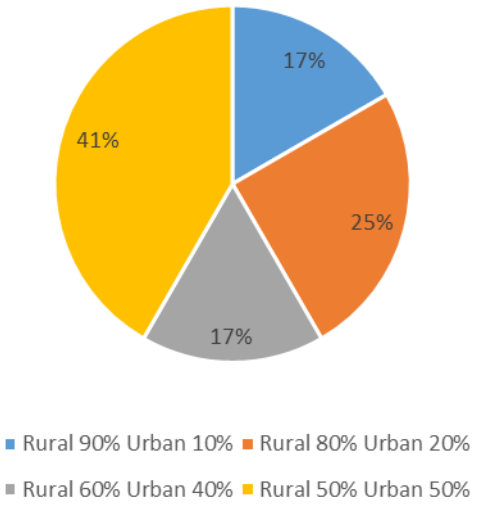

Figure 2 Split between Rural and Urban Travel

Vehicle efficiency is important when considering the environment. The findings show that Miles per Gallon (MPG) can substantially vary depending on the type of vehicle used. The lowest MPG was 6 and the highest was 10. Thus, Table 4 indicates that newer vehicles can achieve 40% more miles per gallon than older ones. It is important to recognise the effect this has on the environment. Table 4 indicates that the quarries using the most polluting vehicles can reduce pollution by as much as 16.9% when taken as a percentage of the miles travelled per year. Comparing like with like, there was 3 tonnes more CO2 produced from a vehicle with a MPG of 6 compared to a vehicle that had a MPG of 7. This shows the importance of upgrading vehicles to more efficient ones as it has a significant impact on the environment. This supports the findings of Zuoa *et.al.* (2013), who examined the effect of lowering emissions through the efficiency of the vehicles.

The survey did show that some quarries were covering up to 140 miles per trip on the island of Ireland while others were only delivering within 15 miles with a 30 mile round trip. This shows the different locations of demand. The more quarries in a certain area the further they appear to deliver. This may be due to competition and saturation nearer the location. Geological constraints impact on quarry locations but the effect of transport should be taken into account in the planning process. The Planning Strategy for Rural Northern Ireland (PSRNI) does have policies that deal with transportation but it does not take into consideration the effects of mileage and the importance of updating vehicles to make them more environmentally friendly.

Table 4 CO2 produced per year (tonnes) per quarry calculated through average mileage & MPG

Survey ID	Miles	MPG	CO_2 Tonnes / year	CO_2 Tonnes / quarry / mile	% above lowest
10	50	7	18.12748	0.363	+10.9
13	200	9	56.39661	0.282	+2.8
2	50	6	21.14873	0.423	+16.9
25	100	6	42.29745	0.423	+16.9
20	50	7	18.12748	0.363	+10.9
28	50	6.4	19.82693	0.396	+14.2
14	75	10	19.03385	0.254	0
22	200	7	72.50992	0.362	+10.8

Additionally all quarries stated they were not aware of Government planning Documents which deal with the effect of Lorries on the environment. Information about regulation and content of these documents needs to be made more accessible for quarries so that they can stay up-to-date with information and receive reminders of the importance of and changes to the planning documents in relation to the environment. The time to disseminate this information and put into place regulation is now as 66% of quarries intend to renew their current fleet of lorries, and 44% intend to expand their fleet. So in order to maximise the impact on CO2 regulation as to the type of vehicle they are buying new or replacing existing stock with should be adopted. Comments from the quarries prove that when purchasing a new vehicle MPG is the most important factor. Therefore it is important to support this with regulation. This indicates that quarries consider fuel efficiency very important and this will help lower the effects on the environment.

3.4 Findings on Planning Policy and supply

Recycling is an important part of being sustainable and in calculating the overall capacity of aggregate production. Only four quarries of the twelve quarries who responded stated that they practiced recycling. There needs to be an increase in recycling as the future reserves of

aggregate will become exhausted, and the access to these resources will become more difficult as construction of roads and housing continues to increase.

Plans for extension of existing quarries were then examined. Five out of the twelve quarries responded. Four of the quarries who responded (80%) stipulated that planning was a major concern in relation to expansion. Issues raised in relation to planning included "*planning cost associated with overburden removal*" and "*Ribbon Development*". There is one quarry that will close in the next 5 years so planning needs to examine if another needs to be opened to meet the demand.

Only three quarries responded in relation to identifying planning documents in realtion to mineral policies. While current polices in relation to *restoration of sites* and to *deal with noise, dust and pollution* were identified the background planning policies were not. One quarry also identified the need for a mineral policy for the aggregates sector. It would be good if the planning documents in relation to this could collate all the information on mineral extraction and planning into a single location in order to increase access to the required information. This would support the quarry sector allowing it to become more efficient and sustainable as well as environmentally friendly.

4. CONCLUSIONS

This study examined the quarry industry in Northern Ireland from four perspectives: BREXIT, capacity, transport and planning. Responses were received from 12 of the 15 working greywacke quarries in the province.

The findings indicate that as the majority of greywacke excavated is for the home and remainder of the UK market that BREXIT may even increase the requirements internally due to a restriction of imports. However, this is balanced by an expected drop in exports to the Republic of Ireland on the negative side. The production output of greywacke has remained static since the economic crisis in 2007. With this in mind, current demand indicates County Down has sufficient reserves for over 20 years. However, other areas of NI require materials transport, as County Antrim does not have much by way of reserves due to its geology. Planning policies need to take into consideration the geological locations of greywacke and plan accordingly.

The time to produce a standard for vehicle efficiency for quarries has arrived to support those quarries in reinvestment in vehicles. Some of the newer vehicles are achieving 40% more miles per gallon than the older ones and the findings show that this could lead to a 16.9% reduction in pollution. Currently, 66% of quarries intend to renew their current fleet of lorries and 44% intend to expand their fleet so if they could be encouraged to choose on the basis of increased MPG through legislation or guidance this could be an easy win for the environment.

Finally, the findings show that not all quarries are aware of the policy around their work and extra visibility could be attained if all the planning and mineral extraction documentation relating to procedures, planning and use could be collated into a single source document. Further work needs to be carried out to determine the full contents of this but it would support the industry in becoming more efficient and sustainable as well as environmentally friendly.

4. ACKNOWLEDGEMENTS

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